γ–γ fast timing measurements in neutron rich Xenon nuclei

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Introduction:

The even-even Xe isotopes in the west of N = 82 neutron shell closure are known to display the transitional behavior from vibrational to rotational as one moves away from the shell closure [1,2,3]. These nuclei around ^{132}Sn also show octupole correlation, the strength of which decreases with the filling of neutron pairs till N = 82 [4]. The octupole correlation in this mass region may arise either from proton as well as neutron ΔJ = 3 orbitals as both the nucleon occupy the same subshell space. Although in most of the cases the coupling between the proton orbitals are found to be responsible, the coherent contribution of both protons and neutrons may bring in enhancement of octupole correlation and B(E3) strengths [5].

The odd-A isotopes of neutron rich Xe around ^{132}Sn are comparatively less studied and may be interesting in delineating the role of a unpaired neutron in the structure of these nuclei. The lifetime measurements for the low lying states are thus important to explore these rarely studied nuclei, mainly through decay of fission fragments.

The experimental data on both ^{133,135}Xe were limited mainly to beta decay and light ion induced reaction [6]. Recently, multi-nucleon transfer reactions have been used to study the high spin level structure and isomers in these nuclei [7,8]. Level lifetimes are not known for any excited levels in these two nuclei except few long lived isomeric levels, viz., $11/2^-$ and $23/2^-$. Such lifetime data, especially for the low lying levels developed with the excitation of few neutron holes are of extreme importance to understand the nuclear structure around double shell closure of ^{132}Sn. In the present work, the level lifetimes for two odd-A Xe nuclei, ^{133,135}Xe, has been aimed from the decay of radio-chemically separated ^{133,135}I fission products.

Experiment:

The excited levels of neutron rich Xe isotopes have been populated through the decay of radio-chemically separated ^{133,135}I ($\tau_{1/2}$ ~ 20h, 6h) fission products, produced with ^{nat}U(α, f) reaction at E_{beam}= 40 MeV at VECC, Kolkata. The decay gamma rays have been detected with VENTURE array [9] coupled to two Compton suppressed Clover HPGe detectors, as shown in Fig. 1. The pulse processing has been done with NIM electronics and VME data acquisition with high resolution Mesytec ADCs.

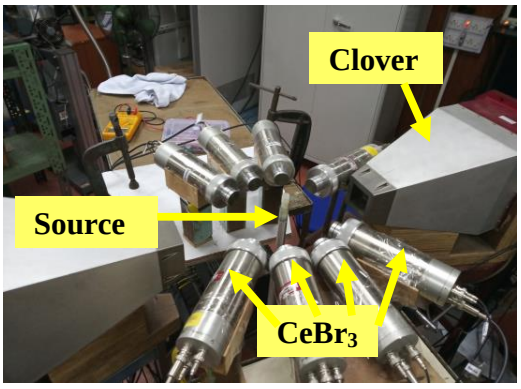

Fig. 1: Experimental setup with VENTURE array and two Compton suppressed Clover HPGe detectors.

The gamma-gamma cascades have been studied with $CeBr_3$-$CeBr_3$, Clover-Clover and $CeBr_3$-Clover coincidence for which the typical energy

and TAC spectra are shown in Fig. 2 and Fig. 3. Generalized Centroid Difference Method with Common start timing [9] has been used to gather gamma-gamma fast timing data from $CeBr_3$-$CeBr_3$ coincidences, for the measurement of level lifetimes ranging from few picoseconds to several nanoseconds. ^{152}Eu, ^{133}Ba and ^{60}Co sources have been used for the generation of the prompt time response of the array.

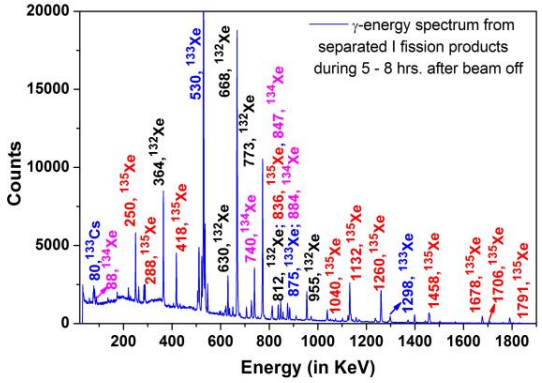

Fig. 2: *The total energy spectra obtained in the present work from the decay of radio-chemically separated Iodine using Clover HPGe detectors.*

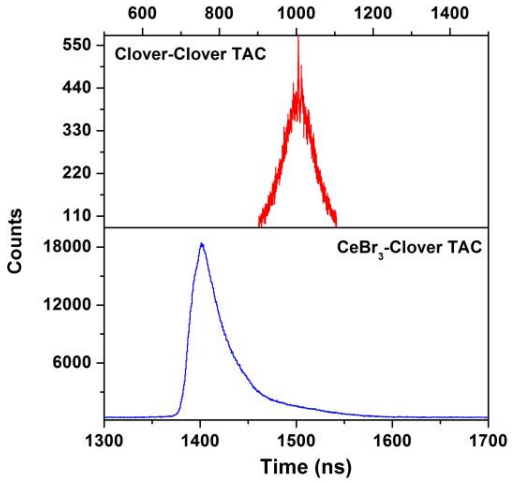

Fig. 3: *The total TAC spectra obtained in the present work from the Clover-Clover and CeBr3-Clover coincidences.*

The shell model calculations have been performed using NUSHELLX code [10] with sn100pn interaction [11] and considering ^{100}Sn as core. The results obtained from the calculation for different low lying levels are shown in Table1. The lifetimes measured in the present experiment will be interpreted in the light of the results from shell model calculation.

Table1: Lifetimes of the levels in ^{133,135}Xe from shell model calculation using NESHELLX

^{133}Xe (E_x keV, J^π)	τ(ps)	^{135}Xe (E_x keV, J^π)	τ(ps)
263, ½$^+$	17100	288, ½+	2300
530, 5/2$^+$	56	1260, 5/2$^+$	2
680, 3/2$^+$	36		
875, 7/2$^+$	5	1131, 7/2$^+$	2

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